THE SYNTHETIC EXPERIMENT.

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§ 1. ANALYSIS AND SYNTHESIS.

Nothing is more striking in the pages of current psychological literature than the extensive record of analytic work. Analysis is, certainly, one of the essential ingredients of the atmosphere of science; and it is not therefore surprising that, with the splendid examples of physics and biology before it, psychology should seriously attempt the reduction of its material to the lowest convenient terms. Although its errors in this regard have been eagerly pointed out from time to time, it is safe to say that the necessity for psychological dissection is not likely to be called in question. But the matter stands differently with the interpretation of analytical results; upon this point turn many disputes. One psychologist contends that analysis is an end in itself: that one goal of the science is to know how mind is made up; what the ultimate bits of mind are. Another, that analysis is an indispensable aid to the study of genesis. Another, that it sets forth the psychophysical couple, and by its help indirect causal explanation is made possible.

Instead of discussing these various views, the writer wishes to point out still another way in which analysis may be turned to account: namely, in breaking ground for a constructive treatment of consciousness.

If an analytic result shows the true elemental constituents, it should be possible, at least in a good many cases, by adding the elements one by one, to rebuild the original experience. Surely no better test of the accuracy of an analysis is possible than the reinstatement of the whole through synthesis of the products of dissection. It is, to put it in another way, theoretically possible to devise and carry out a synthetic experiment on the same plan as an analytic experiment is conducted. If we take advantage of special and constant conditions for the dissection of mind, why may we not as well make use of these conditions in building up mind again? To make the matter concrete: why should we not, if we find that liquidity is a perception made up of a number of known elements, bring these elements together artificially and produce the perception in

question? There is surely no new theoretical difficulty, at least. The present article proposes a very brief outline of experimental syntheses with one or two concrete instances worked through in detail.

It scarcely needs to be pointed out that the type of synthesis which is to be discussed is entirely different from the genetic type.[1] It is one thing to build up the identical consciousness that has just been dissected, and quite another to take the dissected bits of, say, the normal, adult consciousness and entrust them, as protopsychic units, to time for the creation of a mental phylogeny. Very grave objections may be made to the second procedure.

In general, our synthetic experiment will consist just in putting together artificially the elements into which we have previously dissolved a complex experience. The experiment will be a psychophysical one, as the analytic one usually is, because it will manipulate the conditions under which the experience arises. The tests of its validity will be two: (1) it will produce the experience without extraneous suggestion, and (2) it will produce the experience only when all the elements which it includes are present. When its validity is assured, it will furnish an absolute check upon analysis.

The artificial construction of consciousness is not, indeed, an esoteric process known to psychology alone. The alchemy of æsthetics has used it for centuries. The pictorial vehicle for conveying beauty is a fabrication of psychological elements. A crayon or a pigment gives the adequate stimulus to a color or brightness sensation, and the premeditated arrangement of these is the visual colligation which the artist *uses* to express his conception. The more fully the actual elements present suffice to elicit the psychological complex, the more truly is the operation a synthetic one. For there are very different degrees of synthesis. A bit of shadow in the woods may touch off the perception of a mounted warrior, or of a deep cleft in the soil, but only by way of suggestion. The actual presentation calls forth a very meager conscious reaction if the proper trend to consciousness be lacking. It is, one may say, only the train which explodes the mass of material already gathered and arranged. In the truly synthetic experiment, on the other hand, the materials are carefully sorted, brought together and fed to the psychophysical machine. Thus in the production

[1] The latter type is represented by Dr. Stout, who first makes an analysis of mind (*Analytic Psychology*) and on the basis of this analysis (see preface) constructs his scheme of development (*Manual of Psychology*), starting with the sensation or the 'sensation-reflex,' "the most primitive form of mental life which is distinctly recognizable" (Manual, p. 126).

of a painting, the æsthetic pronouncement which is called forth cannot be said to be synthetized, but only the color-brightness colligation from the pigments and the canvas.

§ 2. The Province of Synthetic Experimentation.

It follows from what has been said that the range of synthetic experimentation is much narrower than that of analytic. The former avoids suggestion and works only where all the factors can be easily controlled. The experimenter here copies nature. He sits, for the time being, before the "whirring loom of time" and plies the weaver's craft. Either he presents a bit of made-to-order environment to the organism which he considers for the moment as merely a psychophysical receptacle, or he manipulates the factors in a conscious movement or an emotion, contemplating the mind as a theater for staging a characteristic action or a dramatic situation.

It is not always easy to decide when one is reconstructing synthetically. As has just been pointed out, a mere cue to the organism, which sets up an elaborate reaction, is not to be regarded as a synthetizing stimulus. Suggestion must play no more or less important part than it does in the face of the usual 'normal' situation in experience. Where nature has compounded a situation, experiment simply stands in her stead.

The second difficulty arises from the similarity between our experiment and certain forms of illusion. This applies within the field of perception. The term "illusion" is used broadly and loosely in psychology. It may include, for example, every kind of trick to which the normal consciousness is liable. Tricks from the nervous mechanism (*e.g.*, phenomena of double conduction); tricks from peculiarities of the sense-organs (*e. g.*, the binocular vertical); tricks from association (*e. g.*, the size of the moon); tricks from judgment, memory, imagination, apperception. Since we have no definitive account of illusions from a systematic standpoint, it is useless to attempt a clear description of them. One has only to recall the multitude of theories: "intellectual," "perspective," "contrast," "confluxion," "mechanico-æsthetic," "physiological," and the host of interpretations, to convince oneself not only of the lack of finality in arrangement and explanation, but also of the heterogeneous nature of the matter crowded under the general heading.

The subject of illusions spreads itself over well nigh the entire field of psychology. Even within the geometrical illusions of sight—the type most thoroughly worked over—we have, without doubt, a number of distinct cases, arising from a variety of conditions. There will be no cause then for confusing the *general* field of illusions and the quite definite class of syntheses.

If it be insisted that both illusion and synthesis imply trick-

ing, it may be answered that from the psychological point of view a trick is the essence of neither. An illusion, as experienced, shows no trace of deception. It is simply a straight-forward experience which has, for psychology, no price set upon it. Only when it is given a value in a general system of experiences is it found to stand at a discount. One may say in the same way that the synthetic perception contains in itself nothing like deceit. It is made up of a collocation of *bona fide* elements. It is only when one views the perception externally, looking into the elements one by one, that one sees traces of the artificer.

Doubtless, instances will arise which we shall be inclined to classify both under illusions, as they are now conceived, and under syntheses, in the sense of the text; but this furnishes no reason for identifying the two classes.

To avoid confusion, the following points of difference between the illusion and the perceptual synthesis may be noted.

(1.) An illusion reveals a discrepancy when brought into juxtaposition with similar experiences; a synthesis does not.

(2.) An illusion may depend upon other factors than environmental (eye muscle strains, fixation), or may even arise without any peripheral stimulation (as an illusion of memory); a perceptual synthesis depends upon environmental circumstances only.

(3.) An illusion may be entirely compounded by nature (as the illusion of the size of the moon); a synthesis depends upon experimental artifice.

(4.) An illusion may arise in one part of an experience-complex through the operation of an adjacent part (*e. g.*, many optical illusions, as the parallel lines in the Hering and Zöllner patterns, the Müller-Lyer lines, interrupted extent, the inscribed square): in the perceptual synthesis, the perception is a unit; all elements retreat into the background and unite in producing the perception.

In general, illusion implies perceptual torsion. The cause for the torsion may lie either within or without the organism.

The individual builds his world under the guidance of convenient norms and units. This guidance is absolutely necessary, since experience varies from time to time and from circumstance to circumstance. When, now, a given experience is found to vary from its appropriate norm, the individual is said to fall into an illusion. The norm is violated or the unit changed in value. The synthesis, however, is compounded from nature's 'standard' prescriptions, but not at her hands. The general formula reads, for the cases which we have cited: $\alpha + \beta + \gamma = P$, where the small letters stand for the ingredients, and P for the resulting perception. If we write for the ordinary perception, $a + b + c = P$ we shall have for the illusion $(a^1 + b^1) + c = P^1$,

where $(a^1 + b^1)$ represents a partial change in the situation which 'distorts' P. The expression $\pm (P^1 - P)$ would stand, then, for the quantitative measure of the illusion. If now the torsion be given artificially the last equation will read $(\alpha^1 + \beta^1) + c = P^1$. The parenthesis indicates that a *group* of elements is usually manipulated in the illusion, whereas each element stands for itself in the making of the perfect synthesis.

We have, finally, to distinguish experimental synthesis from a group of experiences in which quite a simple stimulus produces not its normal (usual) effect, but a new one. Take, as an instance, the apparent movement of a bright point fixated in an absolutely dark field. Movement is perceived, although the adequate stimulus to movement is probably lacking; there is, however, no deliberate synthetizing of the perception. If, on the other hand, a rapid succession of exposures, slightly different (as in the zootrope), be made, under suitable conditions, the movement perception is easily compounded.

§ 3. Types of Experimental Synthesis.

All the instances that have been cited, thus far, are instances of perceptual synthesis. They are syntheses of the first order; they stand on the lowest level of concrete experience and their constituents are the simplest possible. A good many instances of this type might be given. In vision, we have a typical instance in the stereoscopic representation of depth. Analysis has given the 'dimensions' of binocular space perceptions; stereoscopy has put some of these together synthetically. The pseudoscope, too, furnishes the conditions for a similar synthesis; and, finally, the stroboscope completes the synthesis of a third great class of visual perceptions.

Professor A. Kirschmann has given a good example of the synthetic procedure in vision in the artificial construction of metallic lustre done in connection with his study of the parallax of indirect vision (*Philos. Stud.*, XI, 147 ff.). After recalling the possible visual factors—qualitative, intensive, spatial and temporal—into which the perception of lustre can be analyzed, he proceeds, by elimination, to select the real elements. These he synthetizes in an *experimentum crucis*, and succeeds in constructing artificially (by means of gelatine sheets, etc.), the perception in question. This instance is peculiarly instructive because it shows the value of the synthetic experiment in case direct experimental analysis must, of necessity, be replaced by indirect and logical processes.

Closely allied to Kirschmann's experiment, is Wundt's synthesis of the reflection of objects, in their proper colors, by a colored, highly polished object. The synthesis is made for both monocular and binocular vision by the use of reflected images.

(*Cf. H. and A. Psych.*, 199 ff., and *Grundzüge d. physiol. Psychol.*, 3rd ed., II, 177-8.)

In audition, the scope for synthetic work is not so broad as in vision; neither has the field been so well covered. Still, we have the synthesis of sound localization by the adjustment of binaural intensities and the synthesis of the note by the fusion of fundamental and overtones. There is still room for much construction in creating the clang-tint of instruments by intensity gradations among the partials, and the addition of appropriate noises.

Among tactual perceptions, involving cutaneous and subcutaneous sensations, there is still more to be done. These perceptions will be taken up somewhat fully later; hence a discussion of them here may be omitted.

Finally, our programme of perceptual syntheses demands a place for taste and smell complexes. These senses are very strongly affective and quite weakly perceptive when they stand by themselves. Odors, it is true, betray by their names a strong tendency to arouse ideas—they are active incentives to association—but for this very reason they do not serve well in the class of experiments which we are considering. They are too suggestive. We get, however, some fairly good synthetic material by the addition of tactual factors to taste and smell. The perception of many drinks—as cider, lemonade and wines—is probably quite capable of synthetic imitation through these three factors.

Are there, we have to ask now, synthetic experiments outside perception? Is artificial construction feasible in any other way than by bringing to the organism elements which, when taken in together, mean an object-in-the-world? Let us look at some other forms of consciousness for an answer to this question.

We turn naturally from perceptions to feelings, because feelings stand on the same general level as the simpler perceptions. But when we attempt to synthetize feelings various difficulties confront us. (1) Pleasantness and unpleasantness, the most prominent elements in the feeling, denote a more general reaction than sensation and are, therefore, less amenable to control. (2) The sensations most prominent in the simple feelings are organic; hence they are less accessible to experimentation. (3) But the most formidable difficulty is this: a simple stimulus conditions at once the sensation and the affection. Piecemeal construction of the complex is, for this reason, impossible.

When, however, we ascend to the level of the emotion, we find that these difficulties are less serious than in the case of feelings. Indeed, if we were to work upon the basis of a 'Reverberation' theory, the reconstruction of all the typical emotions would be conceivable. Instead of a situation acting

indirectly upon muscle, gland, blood vessel, and viscus, the function of these would be altered more directly and in such a way as to kindle the emotion. It would, doubtless, be asking too much of such a theory to expect a reproduction of all the emotions under experimental conditions; but certain of them ought surely to lie under control.

Professor James remarks (*Psychology*, II, 450) that "the immense number of parts modified in each emotion is what makes it so difficult for us to reproduce in cold blood the total and integral expression of any one of them. . . . Just as an artificially imitated sneeze lacks something of the reality, so the attempt to imitate an emotion in the absence of its normal instigating cause is apt to be rather 'hollow.'" Still, he shows later that not only are 'objectless' emotive states common in mental pathology, but that voluntary arousal of emotions is quite possible within limits (462 ff.). Lehmann criticises Lange (*Hauptgesetze, etc.*, 114 ff.) for his identification of ordinary emotions and those simulated by the use of drugs. He himself contrasts the "normal" emotion (the emotion arising in face of a situation) and the artificial. The essential difference is, he thinks, that the first is consciously motived, while the second is not. Considered psychologically, then, the normal and the artificial emotion cannot be identical, though both may lead to the same changes in motor innervation.

So far as the matter of emotive architecture turns upon a point in theory it may, of course, be neglected, since the present outline aims only at indicating a general scheme. Evidently, the success of the synthetic procedure depends, in the present case, upon the true nature of emotion and the essential conditions which underlie it: matters which we cannot discuss here. Even though we adopt Lehmann's conservatism, we may still include simulations under emotions, and thus make a way for our method.

One must by all means guard carefully the purity of the emotive synthesis: one must ask whether all the necessary conditions have been actually arranged for, or whether association (as association of facial contractions, swallowings and forced tears with sorrow) takes the event well toward the limits of the experimental type. These are questions for experiment and introspection, not for theory, to settle. We cannot say that, at present, there is any satisfactory method known to experiment for synthetizing an emotional state by way of its immediate physiological conditions. Nevertheless, the success of crude attempts at producing fear, sorrow, and joy makes the case hopeful.

But more important still is the fact that the reconstruction of an emotional situation is among the resources of the laboratory.

Of course the synthesis does not issue from the simplest elements as in the perception; but that is scarcely to be expected in so complex a consciousness. It must also be said that the emotional situation is so often a matter of human relationships that no hard and fast line can be drawn between natural and artificial instances.

We have still to discuss the class of experimental syntheses which have been, thus far, most serviceable to psychology: the class of artificially synthetized *actions*. Action, particularly in its simplest forms, is so fleet-footed that introspection has well-nigh despaired of overtaking it. It is by all means desirable that it be brought within bounds. This is accomplished by the Reaction experiment. Whatever else the Reaction experiment accomplishes, it gives the coveted opportunity for building up, piece by piece, conscious action as simple or as complex as the psychologist desires. If action included only movement and its results in consciousness we should be dealing simply with another case of perceptual synthesis: the perception of movement. But action is more; it starts with the apprehension of a stimulus, runs through various intervening processes, which vary with the type of action, and issues in movement.

The limits of the action-synthesis are these: (1) it brings the action-stimulus to the organism instead of allowing it to evolve centrally (as the result of ratiocination, *e. g.*); (2) it presupposes rather than creates an action attitude: that is to say, it gives a stimulus which would not necessarily lead to action under natural conditions; only when the connection of action with the artificial stimulus is arranged beforehand is the action completed. Finally (3) the purity of the synthesis is somewhat impaired by the central concomitants (memory, expectation images, choice, etc.) of action.

These limitations are, however, not so serious as they seem to be at first sight, for (1) the objective situation is the usual and, without doubt, the original incentive to action; again, (2) with numerous repetitions, the artificial stimulus assumes more and more the characteristics of the normal excitant to movement; and, lastly, (3) although the synthesis is not pure, the situation is actually reconstructed and the central accessory processes are controlled by variation of conditions.

We found in synthesis of the first type that the more one interpolates associative processes the farther one gets from pure synthesis. Now such processes do come in prominently in various forms of compound reaction, as well as processes corresponding to the logical terms judgment, inference, reasoning; but there is a difference. There the processes were interpolated quite loosely and took us beyond the immediate perception. Here they are not only integral parts of the synthetized action, but

they are directly controlled by the terms of the experiment. The importance of this type of synthesis does not need to be urged. The fact that psychology is able by its means to construct any grade of action from psychomotor to highly involved ratiocinative action, and thus to study the whole range of the action consciousness, shows its great usefulness to the science.

We must not in thus extending the limits of synthetic experimentation overrate its results. Even though we are successful in building up, for example, a perception out of the products of analysis, we cannot say, straightway, that a complete description is given of the structure of the perception in the enumeration of the elements. Putting the case in psychophysical terms, we are not warranted in saying that because a stimulus complex $\alpha + \beta + \gamma$ supplies the necessary conditions for the appearance of a given perception, the perception *is* only the sum of the elements which the stimulus represents. This may be true, and it may not: the synthetic experiment does not determine. Whether there are such things as "Tongestalten" or "Raumgestalten," "Gestaltqualitäten," "Complexionen," and "fundirte Inhälte," the synthetic experiment cannot decide. The discussion of these things turns upon the question as to *how* consciousnesses are put together: whether by a summating, or a consolidating, or some other process.

We seem at first thought to secure in the synthetic procedure all that was lacking in justification of analysis: namely, the assurance that it has dissolved the matrix of mind-stuff and got hold of all there is of it; but we find that we have only added the fact that the elements do work when put together thus and thus; not what is in the product, or sum, or creation, whichever it may turn out to be.

The justification of analysis that we have found is, then, a justification of particular cases. The validity of analysis, in general, we have not touched. As we said at the outset, we verify an analysis if, by reversing the analytical process, we come back to our starting point. The question whether or not mind, considered organically, but quite anatomically, is more or less than, or equal to, the sum of the abstract elements which our analysis reveals must be answered from a different plane from that of the present discussion. We hope to consider this question in another connection.

Leaving, now, the general aspects of the subject of synthesis, we come to the treatment of a particular set of problems which our method encounters; and finally, to the record of a single experiment in synthesis.

The class of perceptions that we have chosen are those arising through stimulation of the tactual organs, and the particular synthesis the artificial construction of liquidity.

§ 4. Synthesis of Cutaneous Perceptions.

The skin is burdened with offices. One of the surprises of physiology is the revelation of the multitude of functions performed by this apparently simple organ. As a rind it is not only the container, but the warder-off, and also the go-between for the organism and its world; tegument, buckler, interagent. It is small wonder that its work is represented in mental process; that many of our most worn and useful perceptions are made up of cutaneous sensations.

The antiquity of tactual perceptions—sharpness, bluntness, smoothness, roughness, wetness, softness, hardness, resistance, tickling, itching, traction, movement, and projection from the body-surface—must be very great. Most of them have had a high survival value in the race's history. The skin as the primitive sense-organ had for a long time to fight its own battles. It has come out not only unscathed but with its susceptibility greatly reinforced by the conflict. It breathes mind at every pore. Its tissue lies packed with sensation, waiting for its Helmholtz to spell it out.

Something has indeed been done in recent years to unravel the tangled skein of perceptions whose origin lies at the borders of the organism. Analysis has cunningly searched out the elements of the complexes and has pointed to the specific organs which condition them. Much systematic work remains. And a good deal of this will consist in putting together what has already been abstracted from the total mass. A bit of this construction we have attempted in the remainder of the study.

Liquidity.

A good deal remains to be done here by way of preliminary dissection. The apprehension of wetness is commonly considered something unique: the finger touches a wet surface, or the hand is plunged into a liquid, or the body is immersed, and one is said just "to feel wet." This is a striking instance of the confusion of mental processes and their significance; in this case, a confusion of sensation with perception. It is, moreover, hardly likely that liquidity is perceived through even an unique kind of sensation. Working then under the rule of the Law of Parsimony an attempt has been made in what follows to reduce liquidity to known sensational elements—we have pressure, pain, thermal,[1] tendinous, muscular and articular sensations to draw upon—and afterward to synthetize it *de novo*.

i. A series of liquids of varying specific gravities, degrees

[1] A striking case of thermal synthesis, worked out by S. Alrutz (*Mind*, 1898), p. 141, is the production of the 'hot' fusion by means of the simultaneous stimulation of warm and cold organs.

of viscosity and volatility was collected. This included mercury, petroleum, eldorado oil, water, molasses, benzine and ether.

In giving the stimuli, the first and prime precaution was to rule out other senses than the cutaneous and subcutaneous. The eyes were bandaged or kept closed, the nose (and when necessary the ears) stopped with cotton, and the member used kept quiet, or moved only under definite control. The middle finger of the right hand was used in most cases. Control experiments were made with all the fingers, with the palm, and with the whole hand and wrist.

With these limitations the perception of liquidity was marvellously narrowed down and simplified. The eyes and the nose are extremely useful (as in many other perceptions) in helping out the skin.

Instead of moving the finger into and out of the various liquids, it was found best to place the arm comfortably on a rest with the finger projecting over the edge, and then to raise and lower the containing vessel (a beaker of convenient size).

To avoid quivering of the liquid, the beaker was set in an elevator which was operated by a cord run over a pulley at the ceiling and wound upon a small drum. The drum was revolved very slowly and steadily by means of a long crank.

Suggestion was avoided just as far as possible. The subject was brought, eyes blindfolded and nostrils stopped, from an adjoining room before each experiment. The experiment consisted of three parts: (1) contact of the finger with the liquid surface ("ad"); (2) immersion of the finger about as far as the first joint ("in"); and (3) withdrawal from the liquid ("ex"). The test began as soon as the subject was comfortably seated; a warning signal (for the attention) was given before each of the three parts. The subject gave a running introspective account during the experiment and completed it immediately afterward. The operator kept the record-book. From four to nine records were taken in an hour.

Dr. W. B. Lane (L.) and the writer's wife (S.) kindly served as subjects. The writer acted as operator and occasionally as subject. The work was carried on in this laboratory during the winter term of the present year.

Results.

Before the investigation had proceeded far, it became evident that the cutaneous processes, when isolated, function rather clumsily: differences in density, viscosity, etc., passed unnoticed when color, transparency, odor, sound and lateral or irregular movements were wanting. For example, molasses, benzine and even mercury passed under certain thermal conditions for

water: an indication of how widely the organism is obliged to draw upon its resources for the completion of so simple a perception as that of a liquid.

The Tables which follow show the results for mercury, benzine and water: a heavy 'dry,'—a light volatile,—and a moderately heavy liquid. Results from the other liquids used need not be tabulated. The oils—petroleum and eldorado—stand between water and mercury in specific gravity: their oiliness disappeared under the conditions of the experiments. Only when there was a jar of the vessel, or a sudden movement of the finger, or a rubbing of two surfaces, was the 'oily' perception obtained. S did not once perceive 'oiliness' throughout the experiments. This perception remains to be worked out under Smoothness and Resistance. When the oils were distinguished from water and mercury, pressure intensity seemed to be the only criterion if the skin alone was concerned.

Ether and benzine gave similar results; the difference being the more intense cold after the removal of the ether.

Let us examine the tables. The stimulus is named on the left, then follow columns for the stage and number of the experiment, the subject, and his report. C = cold; W = warm; P = pressure, etc.; o = present; oo = present at a very high intensity; — = present at decreased intensity. Where no objective temperature is noted the substance has the temperature of the room. Temperatures were not kept in degrees because (1) the zero point of the skin shifts very greatly, and because (2) quantitative results were not in the least cared for, except where they could throw light on qualitative questions.

The results are pretty uniform. Pressure and temperature are evidently the two important factors in liquidity. The record shows that the pressure is of a peculiar kind. It is a close-fitting pressure, strongest at the tip and at the ring (when a ring is present). It has a tendency (naturally) to grow faint as it continues. Often when the member is immersed the subject is doubtful whether any pressure remains. Another peculiarity of the liquidity-pressure is its advance and recession: it creeps up and down. At first the subjects declared that the wetness was something added to the pressure and temperature: it was, for them, unique. Later L found in it a peculiar mixture of warm and cold, especially when a warm stimulus was given. There seemed in the wet to be little spots of cold sprinkled around in the warm.

To test the uniqueness of the 'wet' an experiment was arranged in which pressure and temperature were eliminated, while the stimulus was actually moist. The required conditions were obtained both with water and benzine. L, whose pressure limen for the finger is rather high, got no sensation (water

TABLE I.

Mercury.	Subj.	No.	C.	W.	P.	Remarks.	Ring.	Traction.	Perc'n.	Remarks.
Ad.	L.	1	oo							
	L.	2	o		o					
	S.	3	o		o					
(Lukewarm)	S.	4		o	o					
"	S.	5				Tip in warm air.				
	S.	6	o		o					
	S.	7	o		oo					
	B.	8	o		o					
	B.	9	o		o					
In.	L.	1	—							
	L.	2	o		o	Strongest at tip.	o			
	S.	3	—		o	On ball of finger.	o			
	S.	4		o	o	At tip.	o			
	S.	5					o			
	S.	6					o			
	S.	7	o		oo		o			
	B.	8	—o		—o		o			
	B.	9	—o		—o		o			
Ex.	L.	1			o	Clinging pull, then push.				
	L.	2			o			o		Like water, but P. too great.
	S.	3			o	Dwindled to point.			Hg.	
	S.	4			o	Left at tip.	o			
	S.	5			o	Left at tip.				Warm air till finger moved, then water.
	S.	6			o	Dwindled to point.			H_2O	
	S.	7			o	Dwindled to point.			H_2O	
	B.	8	.o		o	C. and P. disappearing.	o			Did not know when liq. left.
	B.	9	o		o	" "	o			

TABLE II.

Benzine.	Subj.	No.	C.	W.	P.	Remarks.	Ring.	Traction.	Perc'n.	Remarks.
Ad.	L.	1	o		o	P. less than water.				
	Li.	2	o	o	o					
(Lukewarm)	Li.	3								
	Li.	4	o		o					
(Lukewarm)	Li.	5		?						
	Si.	6	o		o					
	Si.	7	o		o					
(Lukewarm)	Si.	8		o	o					
"	Si.	9		o	o	Dry vapor.				
"	Si.	10		o		No wetness.				
"	Si.	11	o			"				
"	B.	12		o	o	"	o			
"	B.	13		o		Difficult to place W.				
In.	L.	1	o		o					
	Li.	2								
	Li.	3	o		?					
	Li.	4	o		o					
	Li.	5	o	o	?		o			
	Si.	6	o	o			o			
	Si.	7	o		o		o			
	Si.	8		o	o		o			
	Si.	9			o	No wetness.				
	Si.	10		o		"				
	Si.	11	o		o	Feathery(dry)P. in patches				
	B.	12		o	o					
	B.	13	o			Cold in patches. Dry.				
Ex.	L.	1						o		
	Li.	2	o					o		Confused *ad*, *in* and *ex.*
	Li.	3	oo							" " "
	Li.	4	o							" " "
	Li.	5	o							" " (Wetness after *ex.*)
	Si.	6	o							" "
	Si.	7			o				Benzine.	
	Si.	8	o							No wetness.
	Si.	9	o							Suppose it has been wet.
	Si.	10	o							No wetness.
	Si.	11	oo							No wetness.
	B.	12		—	o	Turgidity of finger-end.			Light Liquid.	Advancing wet.
	B.	13	o		o					

TABLE III.

Water.	Subj.	No.	C.	W.	P.	Remarks.	Ring.	Traction.	Perc'n.	Remarks.
Ad.	L.	1	o		o					Wet.
(Lukewarm.)	L.	2								
"	L.	3			o					
"	L.	4								
"	L.	5		o		No wetness.				
"	L.	6			o	"				
(Cold.)	L.	7	o		o					Wet.
	S.	8	o		o				Hg ?	Wet.
(Lukewarm.)	S.	9		o	o					
"	S.	10		o						Leaving water, *ad* and *ex* confused.
"	S.	11								
"	S.	12		o	o					
(Cold.)	B.	13	o		o					
In.	L.	1	o		o					
	L.	2		o	?					Wet.
	L.	3	o	o	?					Wet.
(Cold added.)	L.	4	o	o	o				H_2O & Benzine	Wet. Wetter [when cold added.]
	L.	5		o	o	W. delayed.				Wet.
	L.	6	o	o	o					Wet.
	L.	7	o	o	o					Wet.
	S.	8	o		o					
	S.	9					o		H_2O	Wet.
	S.	10								
	S.	11		o	o					Wet. Immersed in liquid.
(Cold added.)	S.	12				Later got P. and C.	o		H_2O	Wet when P. and C. came.
	B.	13			o		o			
Ex.	L.	1	o		o	Receding.			H_2O	Wet.
	L.	2	o		o				Benzine.	Wet. Confused *ad* and *ex*.
	L.	3	o		o					Wetter when out, *i. e.*, cold.
	L.	4								
	L.	5	o	o						Wet at tip.
	L.	6	o	o		Wet going up.				Took *ex* for *ad*.
	L.	7	o	+o						Less wet than at *in*.
	S.	8			o	Receded to tip.				
	S.	9			o	Receding.				
	S.	10	o		o	Entering cool H_2O.				When temp. =o *ad* o *ex* gave no sens. or slight P.
	S.	11	o		o	Slight P. at tip.				
	S.	12								Confused *ad* and *ex*.
	B.	13			—o	Left, cold and wet. P. evaporated.			Liq. betw'n H_2O & Hg	

experiments 2 and 4, *ad:* benzine experiments 3 and 5, *ad*) when the lukewarm liquid was brought over the end of the finger slowly and carefully. Later, when the finger was well immersed, slight pressure and thermal sensations came, and gave wetness. This wetness was increased (water experiment 4, *in*) when cold was added. With S the pressure was not so easily eliminated. Still, where pressure stands without temperature (benzine experiment 9, *in*) no perception of wetness is formed. Similarly, where temperature (either cold or warm) stands without pressure (benzine experiments 10 and 11, *ad*, and 10, *in*) no wetness is given. Even when a feathery, patchy pressure is felt wetness is still absent (benzine experiment 11, *in*). B, also, perceived no wetness from warm or cold by itself (benzine experiment 13, *ad* and *in*).

From these facts we conclude that it is not the actual moisture, as such, upon the skin that gives the perception of wetness.[1] In several cases this has been present, but where either temperature or pressure was lacking 'wetness' was also lacking. An exception is made below for the heavier liquids. Further testimony concerning the elements in the perception will be given in the synthetic experiments.

We have still to note in this connection the differences in the successive stages of the experiment. The only factors which distinguish the perception of being-in-a-liquid from the perception of entering-a-liquid are (1) various changes in intensity and extent of pressure and temperature, and, occasionally, (2) the addition of a ring. The ring itself is easily shown to be only a more intense pressure than the rest, with, sometimes, temperature added. It is usually well-defined in the heavy liquids and vague or lacking in the light.

The upward movement was stopped at *ad*, and, after the report was given, continued. The continued movement was perceived by the subject as an advance of the liquid.

Since the sensitivity for pressure varies at different parts of the finger, the pressure was not equally intense at all places. It was most apparent on the tip and ball of the finger and at the edges of the nail. Still, there were no sharp limits to make the pressure seem patchy.

With the lighter liquids it is seen that the advancing, well-distributed pressure was not sufficiently clear to give the appropriate perception *when temperature was absent.* Mercury, on the other hand, gave a well defined 'snug' advancing pressure and was therefore perceived as liquid even without temperature. But it is a significant fact that mercury, when

[1] We avoided soaking the member; the shrivelling of the cuticle from long exposure to moisture undoubtedly furnishes an indirect means of determining the presence of a liquid.

cold, left a "wetness" after *ex*. Here, again, is a perception of wetness with no objective moisture.[1] The withdrawal of the stimulus was sometimes perceived as a recession toward the tip; sometimes as a mere 'evaporating' decrease in pressure with no change in extent; this with the lighter liquids or with a decreased sensitivity through the continued presence of a strong pressure stimulus. Finally, a bit of traction was sometimes noticed as the stimulus left the finger. This was most apparent with mercury. Whether traction is a unique sensation, incapable of analysis, we shall have to consider later. We find that with the lighter liquids at least—ether, benzine, water—it was not available for the discrimination of entrance and withdrawal. Concerning its peculiar nature we wish to remark by way of anticipation that we found by careful testing that a slight (though supraliminal) traction is easily mistaken for pressure and *vice versa*.

ii. We are ready now for reconstruction. We have found that the apprehension of liquidity when it is confined to the sphere of cutaneous perception consists, in its simplest form, of three parts: (1) entering, (2) being in, (3) withdrawing; that in this form, (a) the 'dimensions' of liquidity are pressure and temperature, and (b) the three parts are distinguished by peculiar combinations of these factors.

If, now, our analysis is correct, we are in a position to verify it by reproducing artificially the perception in the three stages just enumerated.

The first attempt at synthesis was made by stretching lightly a sheet of thin rubber tissue over the top of a beaker and raising the beaker in its elevator till it came in contact (*ad*) with the finger tip (right middle finger, as before). By raising the beaker higher, the finger sank into the rubber (*in*); and by lowering, the rubber was withdrawn (*ex*).

The following notes are taken from the record-book for the first trials.

Subject: L.

I *Ad:* Slight warmth and pressure.
In: Pressure advances half way up nail; clinging, silky, *i. e.*, pressure at minute points.
Ex: Uneven pressure.

II *Ad:* Pressure too firm for a liquid.
In: Same. No advance on finger.
Ex: Pressure left. No traction as from a film.

Subject: S.

I *Ad:* Pressure.
In: Pressure extending irregularly; various intensities.

[1] Another bit of evidence is given by the well-known fact that mercury 'feels wet,' although it is actually dry.

Ex: Pressure left all at once except small place at tip. Semi-solid; perhaps gelatine.

II *Ad:* Pressure.

In: Pressure advancing: film. Pressure uneven.

Ex: Pressure receding: pulled off. Rubber.

The results, though quite negative, are instructive. The temperature and the intensity and distribution of pressure evidently are not right for wetness. To adjust the pressure-element, powdered soapstone was sprinkled on the rubber. Now L, perceived wetness at *ad*, but lost it as the pressure increased. S, who noted that pressure was evenly distributed and came around the finger, perceived a gelatinous substance as before. To relieve the pressure, the point of a burette was introduced to the beaker under the rubber sheet which was blown gently up and down. At *ex* the pressure was made to dwindle to a point by means of air-puffs, and L, then reported a perception of mercury or other heavy liquid leaving the finger. When mercury actually replaced the soapstone on the rubber his perception was the same. Again, the rubber tissue was tried with a breath of cold air driven across its surface. This L, declared to be a wet cloth, touching only near the tip. S, with greater sensitivity, noticed that the cold covered a larger surface than the pressure, and shifted. She thus detected the air blast and failed to perceive wetness.

Various powdery substances,—wheat flour and lycopodium powder,—were tried. The finger was introduced by precisely the same method as before. With L, flour gave at *ad* cold and pressure, and was judged to be a liquid (mercury?); this perception was killed at *in* by slipping and sticking, *i. e.*, irregular pressure; *ex* was observed to be unlike a liquid; there was no smooth, faint dwindling to a point. With B there was no temperature, and liquidity went no farther than "an unbroken film of heavy liquid" at *ad*. At *in* too great pressure at the tip killed the liquidity. S got decided wetness at *in*, with both cold flour and cold lycopodium; at *ad* wetness was doubtful, and at *ex* killed by the clumsy slipping-off of the substance.

To control pressure L, was given flour in a cloth funnel supported by the operator's hand. To simulate the liquid boundary a small brass ring (cold) was on the flour, and the finger was inserted. By carefully changing the shape of the funnel the pressure was regulated.

The introspective account follows:

Subject L.

Flour. *Ad:* Cold and pressure.

In: Greater pressure: more intense inside finger: then more evenly distributed. Ring at surface (pressure or traction?). A liquid.

Ex: Left at point like liquid, but drew off instead of rolling. Traction. Perception: a liquid plus a solid.

A repetition gave the same result, except that there was a jar at *ex*. The liquid at this point was said to be like mercury.

Here the synthesis was entirely successful except at the *ex*. Even here liquidity was not lost; only solidity added.

The effect of the advancing ring by itself was tried on S. A rubber band two millimeters wide was stretched slightly in the thumb and finger of either hand and passed slowly and carefully up the subject's finger. The record follows:

Subject S.

Rubber ring.

Ad: Delicate pressure at tip, and warmth.

In: Distinct ring advancing, and pressure below [doubtless after-image of pressure]; warmth. *A thick liquid.*

Ex: Descending pressure, stuck at one place. This unlike a liquid.

A beakerful of light cotton, slightly depressed in the center, was also used as a synthetic stimulus. With L, the stimulus gave the perception of mercury; this entirely from the distribution of pressure, evidently, since no temperature was sensed. A mercury stimulus had been used a few minutes previously, and the introspective analysis of the two experiences differed only in two minor particulars: (1) mercury gave a ring, and (2) its traction at *ex* was slightly greater than the cotton produced. S got cold and pressure from the cotton, but noticed a slight irregularity in the advance of the stimulus: however, wet was perceived at the tip and remained even after *ex*. (Analysis gave cold and pressure.)

To test this stimulus further the whole hand was immersed in a jar of cotton. L reported pressure and warmth: pressure increasing from "a cobweb-like feel" as the hand was thrust deeper into the substance. No perception was completed until *ex*, when "a heavy liquid like mercury" was reported. The member felt wet when entirely removed from the jar. A repetition gave the same result. S got cold and pressure: at *in* the perception was "clinging, sticky," and later, "perhaps, liquid."

Besides the liquidity perception which comes from immersion, there is the perception of a liquid as dropped-on. The synthesis of the latter was attempted as follows.

Subject L. I. Synthetic stimulus: filled circle of metal on palm.

Report: Strong pressure and cold. Wet? Wet after stimulus left.

II. Air blown on palm from glass tube.

Report: Pressure and cold spreading indefinitely from a point. Wet. Repeated four times with similar result. Twice pressure was not found; four times warm was found with cold. *Always wet:* "a volatile liquid, like ether."

S sometimes perceived a drop of mercury from the air blast, and sometimes perceived the air current (the pressure extending too indefinitely to be a liquid). A stream of cold lycopo-

dium powder was perceived as a liquid, which, however, soon disappeared.

Since the chief difficulty in synthetizing liquidity has been the production of an even, close-fitting pressure, it occurred to the experimenter to arrange a set of conditions which should offer all the advantages of liquid pressure, but which should exclude actual moisture. We saw some pages back that it was possible for a moist substance to be in contact with the skin without giving rise to the perception of liquidity. Now it is proposed to bar out moisture from the liquid stimulus and see whether a perception of liquidity will arise. To this end two methods have been employed. The first is as follows. A rather deep glass jar, eight centimeters wide at the mouth, was filled with water. A weight, two centimeters in diameter, was laid in the center of a large sheet of rubber tissue which was lowered into the liquid, its edges hanging over the sides of the jar. This formed a dry, blind pocket surrounded by water. The pocket was kept closed by the gentle pressure of the liquid. The middle finger of the right hand was inserted carefully, the water causing the rubber tissue to lie close to the skin as the finger descended. Cold (zero centigrade), warm and lukewarm temperatures were used. The results agree for the various observers—L, S, B, and several others. The cold stimulus gave a decided perception of wetness. This was occasionally marred by a slight pull or an unevenness of the tissue. The *ex* was the only part of the perception which was not well simulated. Occasionally it lacked the gradually receding pressure which a liquid gives. Many times, however, the whole course of the synthesis was complete, and did not disappear when the eyes were opened and the actual conditions observed. Warm water gave a less decided wetness, and lukewarm a very faint liquidity or none at all. The substances perceived were water, mercury and liquids of intermediate weight.

The second method was simpler. A thin rubber sheath was drawn over the finger, and the finger lowered into the liquid. The perception of liquidity here was complete, the subjects at first refusing to believe that the finger was not actually wetted. The perception lasted (with cold water) for some time after withdrawal.

Let us see what the net result of our work is. The *analysis* of the liquidity perception is too straightforward to need comment. We found simply that under certain definite conditions the perception could be factored with comparative ease. We then started our synthesis with all our terms known, and with the additional suggestion that moist substances do not neces-

sarily "feel wet." The first step was the bringing together of pressure and thermal conditions in the simplest, though the most artificial, way. The synthesis was, naturally, crude; but in the making we learned to handle our material, hence we were able gradually to eliminate disturbing factors and to make the synthesis cleaner and more clear-cut. We found by working with various materials that the actual substance used—whether a powder, a tissue, a rubber band, or a metal—made little difference so long as it brought together the essential elements in the necessary mode of combination. Having built up quite completely our perception, we turned to Nature for a hint as to refinement of method. We were not disappointed. Taking from her the ingredients which our previous essays had shown to be essential, but rejecting her superfluous ingredient—'moisture'—we got the neatest synthesis so far obtained; thus demonstrating that Nature, even when disabled, speaks to the organism in the most intelligible symbols. To be sure, the outcome of these 'water' experiments is so obvious that any one (with, perhaps, the exception of the experimenter!) might have prophesied it without hesitation. But it will be seen that the tests have a very great importance as they stand in the series.

It is not too much to say, then, that we have given a fair illustration of a somewhat novel, though important, use to which the results of analysis may be put: that we have shown that there is nothing unique in the elemental constituents of the perception with which we have been dealing, and, finally, that out of these constituents we have succeeded in building up, by way of experimental synthesis, the complete perception of liquidity.